MODIS DATA STUDY

TEAM PRESENTATION

March 16, 1990

AGENDA

1. A First-Cut Analysis of Candidate MODIS Direct Broadcast Bands (McKay, Ardanuy)
2. Simulation of Global Land Coverage by MODIS-T: Progress Report (Gregg, Riggs)

A "First-cut" Analysis of Candidate MODIS Direct Broadcast Bands

Although the concept of "Direct Broadcast" of EOS data from the orbiting platform to the user has been widely espoused, particularly by the international earth-science community and upper-level NASA management, many of the operational specifics for this service have not been defined (or at least these specifics, if defined, are company proprietary and not available for general public access). To assist in the preparation of a "first-cut" proposal for MODIS bands to be broadcast, and to provide a basis for assessing the impact of direct broadcast on MODIS data requirements, the following assumptions have been made:

1. Direct broadcast will operate in two modes: a high-gain antenna mode requiring a Landsat or comparable type of antenna and associated receiving equipment, and an "omni" mode that uses an omnidirectional antenna and simpler receiving equipment. The "omni" mode is less costly, and will therefore probably serve a larger user community. The expected data throughput in the high-gain mode is 100 Mb/s; for the "omni" mode, the expected throughput value is 10-15 Mb/s.

2. Direct broadcast data is of primary interest to those regional and local investigators who can realistically obtain required data sets using direct broadcast service. Global researchers require data for the entire earth and will best obtain required data using previosly defined EOS data access channels. MODIS investigators needing real-time support for field experiments or in-situ measurements may also find the direct broadcast service useful or essential.

3. The data system will accommodate the backup use of direct broadcast data in the event of TDRSS failure. The data formats employed in such backup use will be identical to those used for conventional TDRSS transmissions, so that software modification is not required to process MODIS backup data acquired using direct broadcast facilities.

4. Except for such backup use, direct broadcast of data will occur only in real-time as the data is generated by the MODIS instruments. Direct broadcast data will not be retrieved from the on-board tape recorders during normal operation in either of the direct broadcast modes.

5. Real-time user request of specific data items may not be accommodated. The direct broadcast service will provide only one, or at most a few, types of data packets with predefined data content and record formats. Data packet type will not be easily switchable. Most of the time, the direct broadcast system will broadcast a standard data packet chosen for its usefulness to regional and local investigators. "Omni" data will be broadcast continuously without regard to the presence or absence of a data user receiving station. Depending on aiming requirements for the platform high-gain antenna, the high-gain service may broadcast only on user request.

6. If error correcting protocols are used, either in the "omni" or high-gain modes, the formats employed will be compatible with or identical to those used on the TDRSS link, so that data system complexity is minimized.

7. All data transmitted on the direct broadcast link will also be recorded on the on-board tape recorders (as necessary) and redundantly transmitted via the TDRSS downlink.

8. On-board processing hardware for the generation of MODIS products will be minimal. On-board processing of MODIS data to obtain calibrated radiances or derived geophysical products (Level 1-4 data products) will not occur. The MODIS data transmitted by direct broadcast will be Level-0 instrument data. If significant advantages can be achieved using very minimal averaging or subsampling of previously defined Level-0 data, such minimal data processing could be accommodated at the instrument data processors. The bulk of the processing task for direct broadcast data will be accomplished by the data user using his own ground facilities. Synergistic interactions among MODIS data users will be encouraged, and may include such items as software swapping and sharing of results where such techniques can be used to mutual advantage.

9. All platform and ancillary data that the direct broadcast data recipient needs to complete processing will be available in separate data packets and will not need to be included in the MODIS direct broadcast data packets.

Under these assumed operating conditions, it is thought that the high-gain direct broadcast mode can accommodate the entire real-time data stream from the MODIS instruments. Bands for this mode will not have to be selected. It is also thought that the "omni" mode cannot accommodate the entire MODIS real-time data stream, and data volume reduction will be required for this mode. It is assumed that the required reduction in data volume will, if possible, be achieved by band selection, i.e. only data for essential MODIS bands will be transmitted in the "omni" direct broadcast mode.

Tables 1 and 2 are a "first-cut" attempt at selecting a set of MODIS bands useful for direct broadcast in the "omni" mode for the ocean and terrestrial science disciplines. The associated data rates associated with the strawman direct broadcast alternatives are illustrated in Table 3.

TABLE 1.

A "first cut" at selecting ocean bands suitable for direct broadcast in the "omni" mode.

Ocean Sciences			
Proposal A (CZCS class)			
Instrument	Band	Wavelength	Associated product
MODIS-N	9	443 nm	Ocean color
	10	490	Ocean color
	12	565	Ocean color
	13	653	Ocean color
	15	750	Ocean color
	31	11.02 μm	Ocean temperature
MODIS-T	Five Reflected Bands with similar band passes.		
Proposal B (SeaWiFS class)			
Instrument	Band	Wavelength	Associated product
MODIS-N	9	443 nm	Ocean color
	10	490	Ocean color
	12	565	Ocean color
	13	653	Ocean color
	15	750	Ocean color
	16	865	Ocean color
	31	11.02 μm	Ocean temperature
	32	12.02	Ocean temperature
MODIS-T	Six Reflected Bands with similar band passes.		
Proposal C (MODIS class)			
Instrument	Band	Wavelength	Associated product
MODIS-N	8	415 nm	Ocean color
	9	443	Ocean color
	10	490	Ocean color
	12	565	Ocean color
	13	653	Ocean color
	14	681	Ocean color
	15	750	Ocean color
	16	865	Ocean color
	20	3.75 μm	Ocean temperature
	31	11.02	Ocean temperature
	32	12.02	Ocean temperature
MODIS-T	Eight Reflected Bands with similar band passes.		

TABLE 2.

A "first cut" at selecting land bands suitable for direct broadcast in the "omni" mode.

Land Sciences			
Proposal A (AVHRR class)			
Instrument	Band	Wavelength	Associated product
(subsampled)	1	659 nm	Chlorophyll/land&cloud cover
(subsampled)	2	865	Visible cloud cover
	6	1.64 μm	Cloud/snow-ice discrim.
	20	3.75	Clouds/surface temperature
	31	11.02	Window/Surface temperature
MODIS-N	32	12.02	Split Window/temperature
Proposal B (MODIS class I)			
Instrument	Band	Wavelength	Associated product
(subsampled)	1	659 nm	Chlorophyll/land&cloud cover
(subsampled)	2	865	Land cover
	6	1640	Cloud/snow-ice discrim.
MODIS-N	20	3.75 μm	Clouds/surface temperature
	21	3.75	Forest Fires/Volcanoes
	31	11.02	Window/Surface temperature
	32	12.02	Split Window/temperature
Proposal C (MODIS class II)			
Instrument	Band	Wavelength	Associated product
	1	659 nm	Chlorophyll/land&cloud cover
	2	865	Land cover
	6	1640	Cloud/snow-ice discrim.
MODIS-N	20	3.75 μm	Clouds/surface temperature
	21	3.75	Forest Fires/Volcanoes
	31	11.02	Window/Surface temperature
	32	12.02	Split Window/temperature

Table 3. Data Rates Associated with the Strawman Direct Broadcast Alternatives

	MODIS-N	MODIS-T
Along-scan Pixels	1582	1007
# Obs/second/band	12457	6170
Bits/ob	12	12
kbits/sec/band	149	74
kbits/sec/band (214m)	2392	

	Base Level		With 10% housekeeping/ancillary		
	MODIS-N	MODIS-T	MODIS-N	MODIS-T	
Rate for Ocean Option A	897	370	987	407	(KBIT/SEC)
Rate for Ocean Option B	1196	444	1315	489	(KBIT/SEC)
Rate for Ocean Option C	1644	592	1809	652	(KBIT/SEC)

	Base Level	With 10% housekeeping/ancillary	
	MODIS-N	MODIS-N	
Rate for Land Option A	897	987	(KBIT/SEC)
Rate for Land Option B	1046	1151	(KBIT/SEC)
Rate for Land Option C	5531	6084	(KBIT/SEC)

Note: (1) No error correction assumed.
(2) The thermal bands are redundant for ocean and land concepts.

Simulation of Global Land Coverage by MODIS-T: Progress Report

(W.Gregg and G. Riggs)

We are continuing our work simulating MODIS-T orbits to identify potential land coverage. The questions addressed here is: what will be the land coverage if for any scan containing ocean the sensor is ocean mode. The answers to these questions will provide extrema in land/ocean coverage and help to assess the sometimes conflicting needs of the land and ocean sciences.

This report is intended to be a progress report of the activities underway. We have designed computer code to simulate the EOS orbit, and scan characteristics of MODIS-T, as given by T. Magner, Jan. 31, 1990 (MODIS-T Instrument Status Report). Important EOS orbital parameters and MODIS-T instrument characteristics used in the code are summarized in Table 1.

Table 1. EOS orbital simulation parameters and MODIS-T instrument characteristics.

EOS Orbital Parameters

Altitude	705	km
Orbital Repeat Time	16	days (233 orbits)
Period	98.9	minutes
Inclination	98.25	degrees
Equatorial Crossing Time	1:30	local time

MODIS-T Instrument Characteristics

Scan Width	$\pm$ 45°
IFOV	1.56 mrad (0.089°)
Ground IFOV at nadir	1.1 km
Scan time	4.75 secs
Pixels Along Scan	1007
Ground Coverage Along Scan	1500 km (at nadir; no tilt)
Tilt	$\pm$ 50°
Pixels Along Track	30 pixels
Ground Coverage Along Track	32.6 km (at nadir; no tilt)
Successive Orbit Equatorial Crossing Longitude	-24.721°

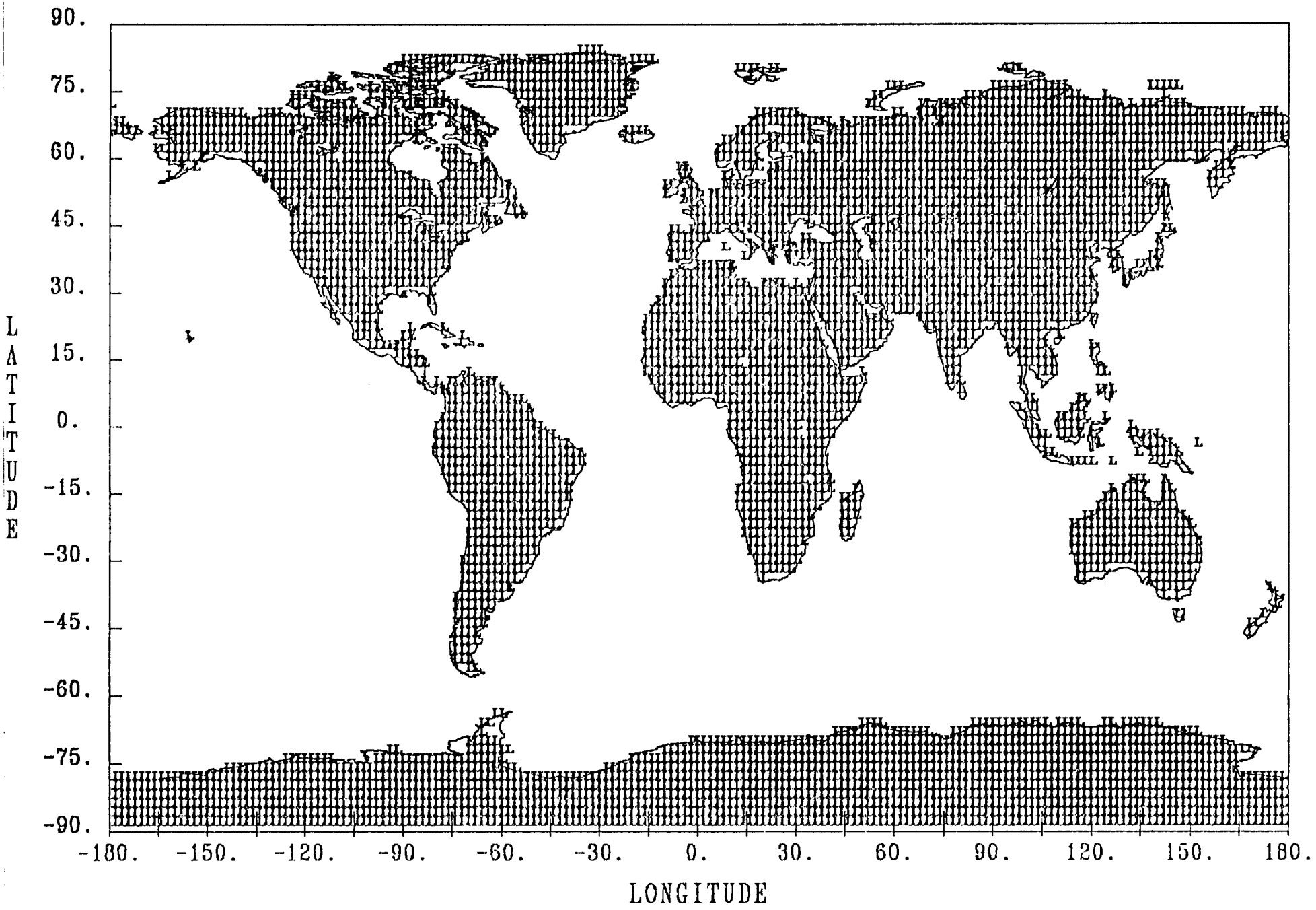
We have obtained the Elaine Matthews Global Vegetation Data Set (GVDS) from the National Climate Data System (NCDS), which is a global map of vegetation types on a 1° by 1° latitude/longitude grid. We are only interested in land vs. ocean, which is

designated index 0 in the GVDS.

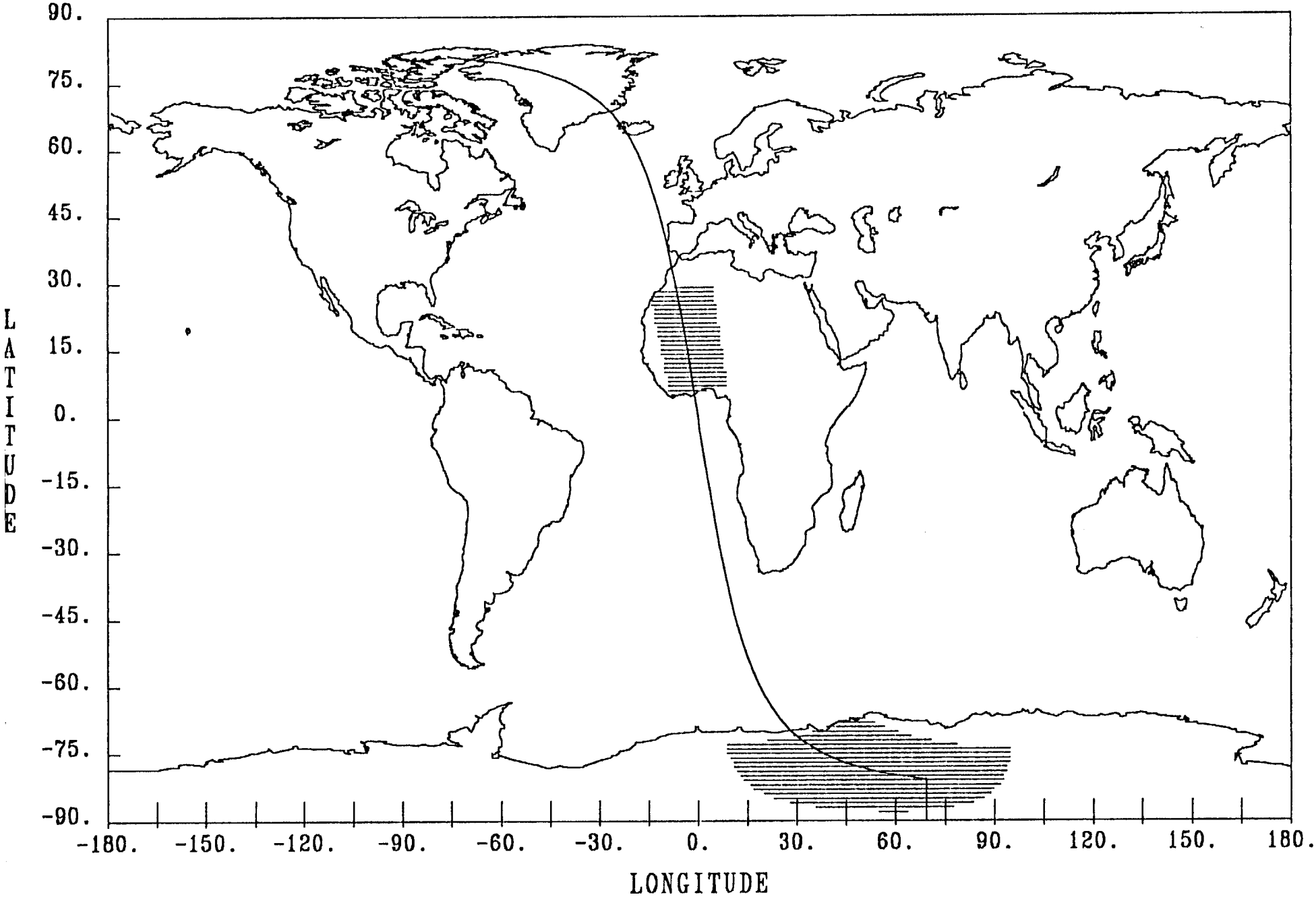
We have developed computer code on the NASA IBM 3081 to plot the scan coverage by MODIS-T, and can generate plots where the scan coverage includes only land. Fig. 1 shows the total land coverage given by the GVDS. An example of Earth coverage by MODIS-T is shown in Fig. 2 for Orbit 1, with an equatorial crossing longitude at the Greenwich Meridian. The horizontal lines are not intended to depict the scan path, but rather the Earth coverage at 1° resolution for scans in this orbit. It is noteworthy that inland lakes, such as Lake Baikal in Asia and Lake Victoria in Africa, are denoted by index 0 in the GVDS. In this simulation, any scan containing an inland lake will thus be considered an ocean scan. We will develop an alternate procedure to eliminate these lakes to gain another perspective.

In the immediate future we intend to produce a full 16 day simulation at 0 tilt. We will then proceed to examine the land coverage under 20° and 50° tilts.

LAND COVERAGE



LAND COVERAGE -- DAY 1



LAND COVERAGE -- DAY 1